Case Report

Cervical Disc Herniation as a Cause of Brown-Séquard Syndrome

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The possible causes of Brown-Séquard Syndrome (BSS) have been frequently observed with spinal trauma and extramedullary spinal tumors, but the cervical disc herniation to cause BSS is rare. The authors present five cases of patients who were diagnosed with BSS resulting from cervical disc herniation, and the results of the literature in view of their distinctive symptoms and clinical outcomes. Postoperatively, the patients showed complete or almost complete recovery from their motor and sensory deficits. On the basis of our cases, it is important to diagnose it early by cervical magnetic resonance imaging, especially in the absence of the typical symptoms of cervical disc herniation or other obvious etiology of extremity numbness. Immediate surgical treatment is also essential for a favorable functional neurological recovery.

KEY WORDS : Brown-Séquard Syndrome · cervical disc herniation · anterior cervical discectomy and fusion.

INTRODUCTION

Brown-Séquard Syndrome (BSS) is a rare neurological condition characterized by a lesion in the spinal cord which results in loss of motor function due to corticospinal tract compression on one side of the body, and a loss of pain and temperature sensation as a result of spinothalamic tract dysfunction on the opposite side. BSS may be caused by traumatic injuries to the spinal cord (e.g., a puncture wound to the neck or back), spinal cord tumors, spinal cord ischemia, infectious or inflammatory diseases (tuberculosis or multiple sclerosis), spontaneous cervical hemorrhages, and degenerative cervical disease (cervical spondylosis and ossification of the posterior longitudinal ligament)[2,11,16-20].

However, cervical disc herniation (CDH) as a cause of BSS is very rare, and only 32 cases have been reported in the English language literature up to now. We report five patients who were diagnosed with BSS resulting from extradural CDH with a review of the related literature.

CASE REPORT

Patient 1

A 31-year-old man presented with a four-month history of neck and right shoulder pain associated with numbness in his left leg and chest, which progressively developed into right hemiparesis. He was then admitted to a local hospital and treated conservatively with anticoagulant medication using high-dose heparin under the diagnosis of a cerebrovascular accident, even though brain magnetic resonance (MR) imaging with diffusion weighted imaging showed normal intracranial findings. Six days later his cervical MR imaging was checked and he was transferred to our hospital. He had no history of trauma to the head or neck.

Upon admission, motor examination revealed 2/4 strength for shoulder adductors, 2/4 for shoulder abductors, 2/5 for elbow extensor, 2/5 for elbow flexor, 3/5 for wrist extensor, 3/5 for wrist flexor, 1/5 for grasping power, 1/5 for ankle dorsiflexion, 1/5 for ankle plantarflexion, 1/5 for great toe dorsiflexion and 2/5 for great toe plantarflexion. Neurological examination revealed that his right hemiparesis had worsened progressively with significant weakness in his right leg, decreased sensation to pain and temperature on his left side below the T4 dermatome, and hyperreflexia with spasticity on his right side, which was in accordance

with a diagnosis of BSS caused by cervical disc herniation. Fortunately, no bladder or bowel dysfunction were found. On deep tendon reflex examination, the left biceps-tendon reflex was reduced and patellar-tendon reflexes were hyperactive bilaterally.

Cervical MR imaging revealed a large right extradural paramedian disc herniation with severe unilateral spinal cord compression at the C3-C4 level. In addition, T2-weighted MR imaging showed widespread high-signal intensity on the right side of his spinal cord adjacent to the herniated disc, an expression of right hemicord damage (Fig. 1). Cervical electromyographic with nerve conduction study showed right C5 radiculopathy, and somatosensory evoked potentials were unremarkable.

A standard microsurgical right-sided Smith-Robinson approach to the C3-C4 interspace was performed through a transverse incision. There was severe compression on the right-sided cervical cord and the nerve root, caused by a large extruded and migrated disc. After complete decompression of neural structures, anterior cervical fusion was performed with a hollow, trapezoidal Cornerstone cage filled with an allograft bone chip. The incision was then closed in layers over a drain and a hard cervical collar was installed.

On his first postoperative day, the patient felt an almost complete disappearance of his right shoulder pain and a significant improvement in his right-sided motor weakness. He was able to ambulate around the ward with no assistance and had only mild right upper extremity weakness (4/5 grade of strength) on the third postoperative day. He was discharged on his 10th postoperative day. The postoperative MR imagings and X-rays taken six months later showed complete decompression of the cervical spinal cord with markedly reduced hyperintensity and bony fusion at C3-C4 (Fig. 2). At the six-month follow-up examination, he showed a complete recovery from motor deficits and a marked improvement in sensory deficits, except for mild right shoulder pain.
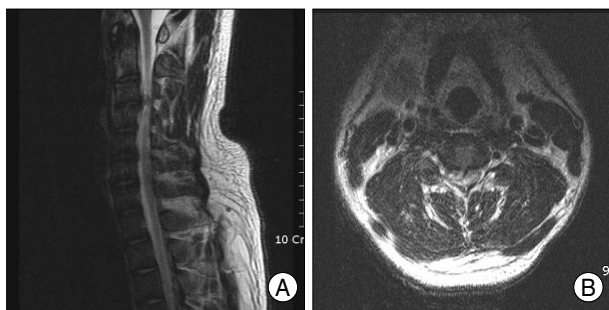
Patient 2

A 66-year-old woman presented with a two-month history of left arm weakness and right leg numbness. One week prior to admission, hemianesthesia developed progressively from her right toes to her buttock, accompanied by left arm weakness. She had difficulty walking and her left-sided motor weakness had worsened. She denied neck pain and any history of trauma to the head or neck.

Upon admission, motor examination revealed 4/3 strength for shoulder adductors, 4/4 for shoulder abductors, 4/2 for elbow extensor, 5/2 for elbow flexor, 4/2 for wrist extensor, 4/2 for wrist flexor, 5/3 for grasping power, 5/0 for ankle dorsiflexion, 5/2 for ankle plantarflexion, 5/0 for great toe dorsiflexion and 5/1 for great toe plantarflexion. Neurological examination revealed left hemiparesis with significant weakness in the left leg. She also had decreased sensation to pain and temperature on her right side below the T10 dermatome, which was consistent with a diagnosis of BSS. Unfortunately, she also complained of bladder and bowel dysfunction. The patellar-tendon reflexes were hyperactive bilaterally.

Cervical MR imaging revealed a large left extradural paramedian disc herniation compressing the left side of the spinal cord at the C5-C6 level, and an additional left para-
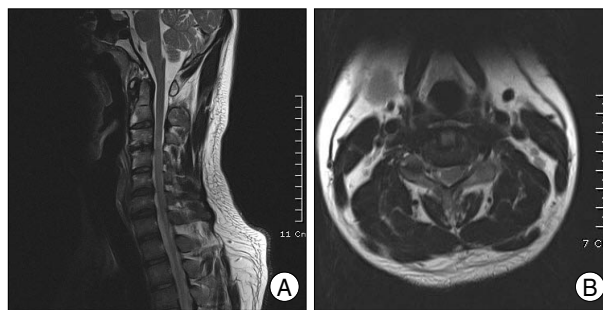
Fig. 2. Postoperative T2-weighted sagittal (A) and axial (B) magnetic resonance images taken six months later reveal complete decompression of the cervical spinal cord with markedly reduced hyperintensity at the C3-C4 interspace in patient-1.

Fig. 1. Preoperative T2-weighted sagittal (A) and axial (B) magnetic resonance images reveal a large right paramedian C3-C4 disc herniation and severe compression of the ipsilateral spinal cord with intramedullary high signal intensity in patient-1.

Fig. 3. Preoperative T2-weighted sagittal (A) and axial (B) MR images show a large left paramedian ruptured and distally migrated disc herniation at the C5-C6 level with a left protruding disc in the C6-C7 space, and severe compression of the spinal cord, in patient-2.

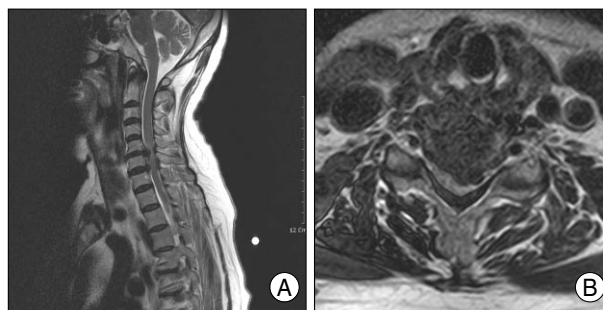median disc herniation at C6-C7. T2-weighted MR imaging showed definitely high-signal intensity in the left side of her spinal cord adjacent to the herniated disc (Fig. 3).

As an emergency treatment, two-level anterior cervical discectomy and fusion were performed using a fibular bone graft with metal plate fixation at C5-C7.

The patient's postoperative course was favorable. On first postoperative day, she showed a significant improvement in left-sided motor weakness and bladder dysfunction. She was able to ambulate around the ward with the aid of a walker on the third postoperative day, and was discharged on the ninth postoperative day. At three-month follow-up examination, her motor and sensory deficits had completely recovered and she underwent postoperative cervical MR imaging and plain radiography, which showed complete decompression of the cervical spinal cord and solid bony fusion of the graft (Fig. 4).

Fig. 4. Postoperative lateral plain radiograph taken three months later shows a two-level anterior cervical discectomy and fusion using an allogenous fibular bone graft with metal plate fixation in patient-2.

The clinical and radiological findings of our 5 cases are summarized in Table 1.

DISCUSSION

It was the first time that the BBS patient was reported in 1846, who had been suffering from traumatic transverse hemisection of the spinal cord due to a knife injury[4]. In 1928, Stookey first diagnosed three cases of BSS caused by CDH[24]. The possible causes of BSS have been reported including, spinal cord tumor, spinal cord ischemia, multiple sclerosis, spontaneous cervical hemorrhages and cervical ossification of the posterior longitudinal ligament[2,11,15,20]. The main pathogenesis of spinal myelopathy is supposed to be ipsilateral compression of the spinal cord caused by spinal cord ischemia due to the unilateral compromise of the radicular artery arising from the anterior spinal artery[17].

Pure BSS with complete hemisection of the spinal cord is very rare. The clinical presentation of incomplete BSS is more frequent, and the neurologic interruption is caused mainly by unilateral involvement of lateral corticospinal tract, dorsal column and ventral spinothalamic tract of the spinal cord[16].

The clinical features are characterized as ipsilateral loss of motor function with contralateral loss of pain and temperature sensation below the level of the lesion, but with undamaged proprioceptive, touch and vibratory sensation due to the sparing of the dorsal column.

The incidence varies according to each author's reports. Jomin et al.[12] reported that the frequency was 2.6%, but their report mentioned no details. In our study, from January 2002 to December 2007, a series of 2,350 patients underwent anterior cervical spine surgery for CDH. Among them, only five cases were evaluated retrospectively, so the incidence was approximately 0.21% (5/2350).

English language literature has rarely reported the associa-

Table 1. Summary of clinical and radiological findings in our 5 patiens

Case No.	Sex	Age	Level	Initial symptoms	Symptom duration	Radicular symptoms	Hemihypea- nesthesia	Intrdural or extradural	MRI hyperintensity	Surgery	Outcome
1	M	31	C3 - C4q	Neck pain, Rt. shoulder pain	4 months	Yes	T4	Extradural	Yes	ACDF	CR
2	F	66	C5 - C6, C6 - C7	Lt. leg weakness, Rt. leg numbness	2 months	No	T10	Extradural	Yes	ACDF	CR
3	M	66	C5 - C6	Neck pain, Rt. shoulder pain	4 months	No	T10	Extradural	Yes	ACF	Mi, Si
4	M	46	C4 - C5	Both leg pain, Lt. Leg weakness	2 days	No	T10	Extradural	Yes	ACDF	Mi, Si
5	F	50	C3 - C4, C4 - C5	Rt. arm pain, Lt. leg numbness	3 months	Yes	T4	Extradural	Yes	ACDF	Mi, Si

ACDF : anterior cervical discectomy and fusion, ACF : anterior cervical fusion, M : motor, MRI : magnetic resonance image, S : sensory, CR or c : complete recovered, i : improved

Table 2. Summary of cases of Brown-Séquard Syndrome caused by cervical disc herniation reported in the English-language literature

Authors	Year	Sex	Age	Dx. Method	DL	Initial Sxs	SD	rSx	Hemih	ID/ED	MRh	Surgery	Outcome
Stookey	1928	M	44	OP	C3-C4	Left leg weakness, neck pain	Nr	Nr	Nr	ED	Nd	Lami	Nr
		M	52	OP	C5-C6	Neck pain	Nr	Nr	T1	ED	Nd	Lami	Nr
		M	68	OP	C6-C7	Neck pain	Nr	Nr	T2	ED	Nd	Lami	Nr
Dürig	1977	M	52	Myelography	C5-C6	Thoracic pain	2 mths	No	Nr	ID	Nd	Lami	Mi, Sc
Roda et al.	1982	M	43	Myelography	C6-C7	Thoracic pain	1 day	No	T2	ID	Nd	Lami	Mi, Sc
Eisenberg et al.	1986	M	25	CTM	C5-C6	Left arm and neck pain	4 days	No	T3	ID	Nd	Lami	Mi, Si
Schneider et al.	1988	F	50	Myelography, MRI	C5-C6	Numbness of left leg, neck pain	1 day	No	T2	ID	Yes	ACD	Mi, Si
Sprick et al.	1991	F	49	Myelography, MRI	C6-C7	Right arm and thoracic pain	10 days	No	Nr	ID	Nr	ACDF	Mi, Si
Finelli et al.	1992	F	28	MRI	C5-C6	Both hand and right leg numbness	18 mths	No	T6	ED	Nr	ACDF	No change
		M	61	MRI	C6-C7	Left hand numbness	8 mths	Yes	T4	ED	No	ACD	CR
		F	46	MRI	C4-C5, C5-C6	Both hand numbness	18 mths	Yes	C4	ED	No	ACD	CR
Rumana et al.	1996	F	56	MRI	C4-C5	Left leg numbness	5 mths	No	T2	ED	No	ACDF	CR
Antich et al.	1999	F	73	MRI	C2-C3	Neck pain	6 mths	No	Nr	ED	No	ACDF	CR
Kohno et al	1999	M	33	CTM, MRI	C4-C5	Nr	1 mth	Nr	T2	ED	Nr	ACDF	CR
		M	31	CTM, MRI	C5-C6	Nr	3 mths	Nr	T4	ED	Nr	ACDF	Mi, Si
		M	38	CTM, MRI	C5-C6	Nr	4 mths	Nr	T2	ED	Nr	ACDF	Mi, Si
		M	34	CTM, MRI	C3-C4	Nr	7 mths	Nr	T2	ED	Nr	ACDF	Mi, Si
		F	45	CTM, MRI	C4-C5, C5-C6	Nr	15 mths	Nr	T5	ED	Nr	ACDF	Mc, Si
Boem et al.	2000	M	40	MRI	C5-C6	Left arm pain and both leg sensory disturbance	5 wks	Yes	Nr	ID	No	ACDF	CR
Clatterbuck et al.	2000	M	40	Myelography	C4-C5	Neck and right arm pain	5 wks	Yes	Nr	ID	Nd	ACDF+ Lami	Mi, Si
		F	52	MRI	C3-C4	Right leg weakness	2 mths	No	Nr	ID	No	ACDF	CR
		M	32	CTM, MRI	C5-C6	Right arm and leg weakness	9 wks	No	Nr	ID	No	ACF	CR
Iwamura et al.	2001	M	45	CTM, MRI	C6-C7	Stiffness and dull pain in the posterior neck	15 mths	No	T2	ID	Nr	ACF	Mc, Si
Kobayashi et al.	2002	M	64	CTM, MRI	C5-C6	Paresthesia in the left leg	6 mths	No	T4	ED	Yes	ACDF	CR
		M	39	CTM, MRI	C2-C3	Neck and right shoulder pain	1 mth	No	T6	ED	Yes	ACDF	CR
Mastronardi et al.	2002	M	36	MRI	C5-C6	Neck and left arm pain	9 mths	Yes	T1	ED	Yes	ACDF	CR
Fujimoto et al.	2004	M	54	MRI	C5-C6	Dysesthesia from Rt. toe to nipple	3 mths	No	T4	ED	Yes	Lami	Mi, Si
Song et al.	2005	F	44	MRI	C5-C6	Left arm and leg weakness	6 wks	No	T5	ED	Yes	ACDF	CR
Kim et al.	2005	M	56	MRI	C5-C6	Right shoulder pain	45 days	No	T10	ED	Yes	AF	CR
		M	46	MRI	C5-C6	Left shoulder pain, Lt. Hand numbness	2 wks	Yes	Nr	ED	Yes	AF	CR
Wang et al.	2006	M	44	MRI	C3-C4	Lt. Arm weakness	45 days	No	C4	ED	Yes	ACDF	CR
Sathirapanya et al.	2007	M	63	MRI	C5-C6	Lt. Shoulder pain	8 days	Yes	T4	ED	Yes	ACDF	CR

ACD : anterior cervical discectomy, AF : anterior foraminotomy, CTM : CT myelography, DL : disc level, ED : extradural, Hemih : hemihypeanesthesia, ID : intradural, Lami : laminectomy, MRh : MRI hyperintensity, MRI : magnetic resonance image, Nr: not reported, OP : operation, rSx : radicular symptoms, SD : symptom duration
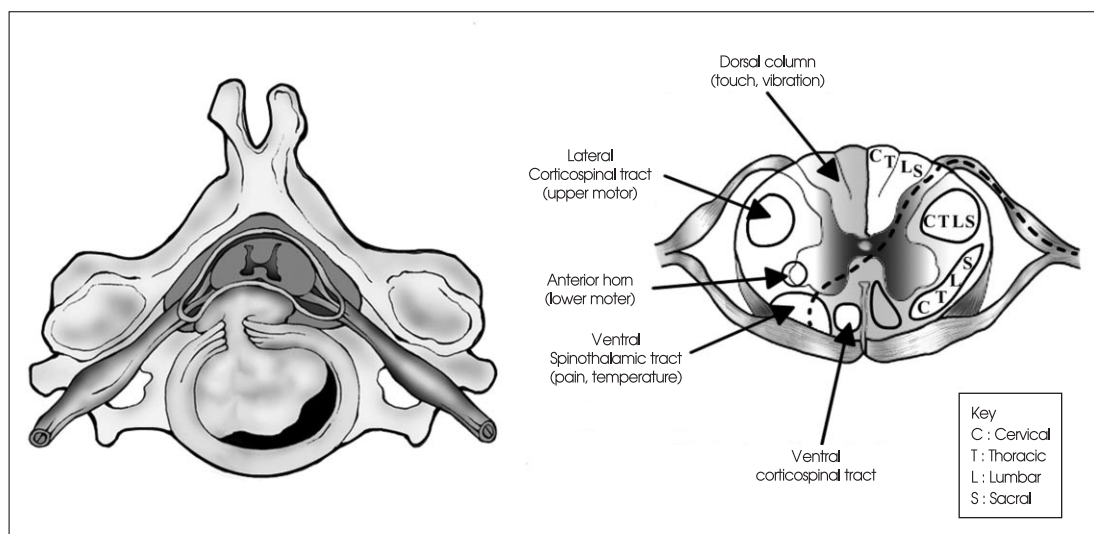
Fig. 5. Diagram of cervical herniated disc compressed lateral corticothalamic tract and ventral spinothalamic tract.

tion between BSS and CDH. In the literature, we found only 32 cases of BSS caused by CDH until now (Table 2)[1,3,5-10,13,14,16,20-23].

The 37 patients including our cases reviewed consisted of 26 males and 11 females. The mean age of males was 45.5 years (range, 25-68 years), and of females was 50.8 years (range, 28-73 years). The disc herniation involved one interspace in 33 cases and two contiguous interspaces in four cases. The levels involved were C2-C3 in two cases (5%), C3-C4 in six cases (15%), C4-C5 in seven cases (7%), C5-C6 in 20 cases (49%) and C6-C7 in six cases (6%). In the majority of cases, the direction of herniation was paracentral[2,4,5,8-12,14-18]. There were 10 cases (27%) of intradural herniation and 27 cases (73%) of extradural herniation. Relevant cervical trauma was demonstrated in two cases of intradural herniation[3,7]. All patients with extradural herniation denied traumatic history. MR imaging was performed on 30 patients, including our own cases. T2-weighted images showed an area of high signal within the spinal hemicord in 15 cases, and no signal change in seven; but there was no mention of it in eight cases. The mean duration of the initial symptoms was 2.4 months (range, 1 day-15 months) in intradural herniation and 5.1 months (range, 8 days-18 months) in extradural herniation. The initial symptoms were numbness of contralateral arm or leg in 12 cases, neck pain in 11 and motor weakness in seven. However, no patients presented with classical radicular symptoms, which likely is because the neural compression observed in these patients is primarily on the spinal cord itself, not the nerve root. Regarding their treatment, all patients promptly underwent surgery after diagnosis. Seven patients (19%) were treated by laminectomy or hemilami-nectomy, three (8%) by anterior discectomy without

interbody fusion, 21 (57%) by anterior discectomy with interbody fusion, three (8%) by anterior corpectomy and interbody fusion, one (3%) by anterior discectomy with interbody fusion along with laminectomy and two (5%) by anterior foraminotomy. The postoperative evaluation of the patients' motor and sensory deficits was favorable in most cases, although minor residual deficits sometimes remained in a few cases. The outcomes of the cases of extradural herniation were better than those of intradural herniation. Complete recovery was occurred in 15 of the 26 extradural cases (58%) and 3 of the 10 intradural cases (30%).

A review of the literature indicates that intradural herniation seems to be associated with an incomplete neurological recovery more often than extradural herniation, because the intradural fragment can directly cause ipsilateral spinal cord damage[3,5-7,10,19,22,23]. Despite the scattered reports of BSS resulting from CDH, the authors are convinced that anterior discectomy or corpectomy with fusion can be the standard surgical modality, because they allow easier exposure, and good decompression, of the pathology, as well as less frequent epidural bleeding, than the posterior approach.

Although BSS is unusually seen in CDH, we may continue to look for it. In particular, current reports of discogenic BSS are increasing because of recent advances in medical technology for diagnosis by MR imaging and widespread information sharing. In most cases, if a patient's symptoms are very subtle and treated conservatively for a long time during the Brown-Séquard phase, the patient will present finally with impending quadriparesis requiring emergency surgical treatment. Patients with CDH commonly have neck pain, cervical radiculopathy, myelopathy and a combination of these symptoms. However, when patients have no cervical symptoms initially, or completely lack cervical

symptoms, this unusual presentation can lead to a delayed or incorrect diagnosis in many wrong directions. For example, because patient-1 was not initially examined by a neurologist or stroke specialist, the acute manifestation of right hemiparesis misled the attending physician to suspect a cerebral stroke. Therefore, careful history-taking and detailed neurologic examination is indispensable as valuable tools for early diagnosis. In particular, MR imaging is the most reliable investigative procedure and should be accepted as an initial diagnostic tool for all cases of progressive spinal cord dysfunction.

CONCLUSION

BSS caused by CDH is a rare neurosurgical emergency and prompt diagnosis using cervical MR imaging, especially in the absence of the typical cervical symptoms or other obvious etiology of extremity numbness, is very important. As seen in our cases, immediate and appropriate surgical treatment is essential for a favorable functional neurological recovery.

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